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GENETIC AND PHENOTYPIC PARAMETERS OF PERFORMANCE TRAITS IN WHITE LEGHORN LAYERS

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Original Article

ABSTRACT

The present study was undertaken to evaluate the genetic and phenotypic parameters of economic traits, i.e. body weight at 20 weeks of age (BW_{20}), age at first egg (AFE), egg weight (EW), egg number up to 40 and 50 (EN_{40}, EN_{50}) weeks of age of egg - type chickens. The data recorded on the flock of White Leghorn layers over five generations (1999-00 to 2003-04) maintained at the poultry breeding farm of Department of Animal Breeding, College of Animal Sciences, CCS HAU, Hisar was utilized for this study. The heritability estimates in different generations for BW_{20}, EW and EN_{40}were low to medium; for AFE were medium; and, for EN_{50}were medium to high. The result suggested that some form of family selection to improve egg production in this flock may be used with some caution to check the undesirable decline in egg weight. Genetic and phenotypic correlations among production traits from the data pooled over generations revealed that BW_{20} had a positive association with AFE, EW, $EN_{40,}$ and EN_{50} at the phenotypic level. AFE and EW had a negative correlation with EN_{40} and EN_{50} at genetic and phenotypic levels. EN_{40} and EN_{50} had positive high association both at genetic and phenotypic levels. In general, standard errors of genetic correlation were higher than the estimates indicating the poor precision of genetic correlation.

KEYWORDS: Correlation, Heritability & Poultry

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INTRODUCTION

The poultry industry in India has emerged as the most dynamic and rapidly expanding segment of livestock economy as evident from the production level touching about 69 billion eggs and 791 million broilers with a compounded annual growth rate of 8 percent and 16 percent respectively (Ramdurg*et al*., 2010). The main driving force for the present revolution in poultry development has been an efficient application of quantitative genetics in poultry breeding methodology. The industry has developed efficient layer and broiler strains within the country, thus, discouraging the import of stock. The currently best commercial layer strains produced (280 to 300) twice as many eggs of acceptable size and quality per bird per year as against their counterpart in 1950's. Efforts in this direction have been made by Indian Council of Agricultural Research through Coordinated Research Projects on poultry and also through numerous *ad hoc* research projects. The revolution has been mainly due to improvement in genetic potential of the stock but these performance levels cannot be expressed in the vacuum. They need acceptable levels of cost, disease control measures, nutrition, flock husbandry and other investments. Still, efforts need to be made to further improve the production potential of chicken stock through the proper application of selection and breeding strategies.

Precise estimates of genetic and phenotypic parameters viz heritability, a genetic and phenotypic correlation among different traits are indispensable in assessing the genetic progress made in different economic traits and in planning the future breeding strategies for their improvement. Keeping this in view, the present study was undertaken to evaluate the genetic and phenotypic parameters of various economic traits.

MATERIALS AND METHODS

The data recorded on the flock of White Leghorn layers over five generations (1999-00 to 2003-04) maintained at the poultry breeding farm of Department of Animal Genetics and Breeding, LUVAS, Hisar was utilized for the study. The progenies were produced in different hatches at the weekly interval during the month of April and May each year. All the chicks were pedigreed, wing-banded at the time of hatching and reared hatch wise using standard managemental practices. The chicks were vaccinated against Marek's disease, Ranikhet, Gumboro and Fowl Pox at appropriate ages. Cockerels were separated from the pullets at eight weeks of age. Two cockerels per dam were retained for breeding and rest were disposed off. At 18 week of age, pullets were housed in individual cages hatch wise. At 20 weeks of age, body weights of pullets were recorded. Trapnest records of each pullet were maintained to record the age at first egg and egg production up to 40 and 50 weeks of age. During 40^{th} week, three eggs from each pullet were weighed and averages of these as considered as egg weight of pullet. The birds were maintained under uniform practices of feeding, housing, and management during the period under study as far as possible. The traits included in the present study were Body weight (g) at 20 weeks of age (BW_{20}), Age at first egg in days (AFE), Egg weight (g) at 40 weeks of age (EW), Egg number up to 40 weeks of age (EN_{40}), Egg number up to 50 weeks of age (EN_{50}). Genetic and phenotypic variances and covariances among the traits, heritability, a genetic and phenotypic correlation among traits from sire component of variance and covariances were estimated using the following model with the help of Mixed Model Least Squares and Maximum Likelihood Computer programme of Harvey (1987).

$$Y_{ijkl} = \mu + G_i + H_{ij} + S_{ik} + e_{ijkl}$$

where, Y_{ijkl} is observation on lth progeny of k^{th} sire in j^{th} hatch of i^{th} generation, μ is the overall mean,G_i is the fixed effect of i^{th} generation (i = 1,2,---5),H_{ij} is the fixed effect of j^{th} hatch in i^{th} generation (j=1………h), S_{ik} is the random effect of k^{th} sire in i^{th} generation NID (0, σ^2e) and e_{ijkl} is the random error associated with each observation and assumed to be NID (0, σ^2e).

For the estimation of genetic parameters in each generation, the above general model excluded the generation effect while hatch was taken as fixed effect as under:

$$Y_{ijk} = \mu + H_i + S_j + e_{ijk}$$

RESULTS AND DISCUSSIONS

In order to know the type of genetic variability affecting performance traits in the population under study, generation -wise and pooled data heritability estimates calculated from sire component of variance along with their standard errors for performance traits are presented in Table 1.

Body Weight at 20 Weeks of Age

The results showed that the heritability estimates for the body weight at 20 weeks of age were low to medium (0.190 ± 0.270 to 0.314 ± 0.105). The results were in confirmation with the findings of Sharma et al. (1999) and Singh et al. (2001). The observed heritability estimates were lower than those reported by Ferdoci et al. (1992), Chaudhary et al. (1997)and Hartmann et al. (2003). The pooled estimates of heritability for body weight at 20 weeks of age were found to be 0.415+0.069. The pooled estimates were lower than those of Singh et al. (1986).

Age at First Egg

Heritability estimates for age at first egg ranged from 0.259 ± 0.095 to 0.368 ± 0.123 in different generations. This trait was found to be medium heritable. Heritability estimates reported in this study was higher than reported by Vasu et al. (2004) and lower than those reported by Ahmad and Singh (2001). The pooled estimate of heritability for age at first egg was 0.431 ± 0.070, which was higher than those observed by Singh et al. (1986).

Egg Weight

Heritability estimates for egg weight ranged from 0.217 ± 0.063 to 0.455 ± 0.128 indicating that this trait is medium to highly heritable. The estimates obtained by Ferdoci et al. (1992) were higher than those observed in the present study. On the contrary, lower heritability estimates were reported by Chaudhary et al. (1997).

Table 1: Heritabilities of Performance Traits in Different Generations

Traits / Generations	BW_{20}	AFE	EW	EN_{40}	EN_{50}
G_1	0.314±0.105	0.259±0.095	0.455±0.128	0.387±0.134	0.579±0.210
G_2	0.255±0.072	0.261±0.730	0.217±0.063	0.239±0.088	0.359±0.103
G_3	0.218±0.094	0.368±0.123	0.387±0.126	0.345±0.137	0.581±0.180
G_4	0.190±0.270	0.263±0.079	0.284±0.083	0.182±0.052	0.504±0.180
G_5	0.267±0.058	0.337±0.090	0.285±0.041	0.209±0.066	0.307±0.095
Pooled generation	0.415±0.069	0.431±0.070	0.491±0.074	0.231±0.072	0.240±0.073

Egg number up to 40 Weeks of Age

The heritability estimates for egg number up to 40 weeks of age ranged from 0.182 ± 0.052 to 0.387 ± 0.134. The estimates were low to medium in different generations. Ahmad and Singh (2001) and Sethi et al. (2003) reported similar to the present finding. Singh et al. (2001) reported low estimates and Hartmann et al. (2003) reported higher than obtained in the present study. The pooled heritability estimates for egg number up to 40 weeks of age was 0.231 ± 0.072. Observed pooled heritability was higher than those reported by Singh et al. (1986). The heritability estimates obtained in the present study as well as reported by earlier workers indicates that egg number is low to moderate heritable and can be improved by following some form of combined selection. The lower heritability estimates are indicative of the increased role of various environmental influences.

Egg Number up to 50 Weeks of Age

Contrary to the heritability of egg number up to 40 weeks of age, the heritability estimates for egg number up to 50 weeks of age were higher suggesting that this flock had a more additive genetic variance for further utilization through selection. The heritability estimates ranged from 0.307 ± 0.095 to 0.581 ± 0.180 in different generations. The estimates

obtained by Atkare and Khan (1988) and Mishra et al. (1992) were lower than those obtained in the present study. The pooled heritability estimate over a generation was 0.240 ± 0.073. Singh (1996) reported lower estimates of pooled heritability than the present one.

Based on the heritability estimates from pooled generation data, it may be inferred that body weight (0.415 ± 0.069), age at first egg (0.431 ± 0.070) and egg weight (0.491 ± 0.074) are highly heritable traits while egg number up to 40 weeks of age (0.231 ± 0.072) and egg number up to 50 weeks of age (0.240 ± 0.073) are low heritable. The result suggested that some form of family selection to improve egg production in this flock may be used with some caution to check the undesirable decline in egg weight

Genetic and Phenotypic Correlations

Genetic and phenotypic correlations among various traits in the present study were estimated by sire component of variance and covariances and are presented in Tables 2 to 6.

Correlation of 20 Week Body Weight with Age at First Egg

Body weight at 20 weeks had the positive genetic correlation with age at first egg in G_1, G_3 and negative in G_2, G_4 and G_5 generations. Positive genetic correlation between body weight at 20 weeks and age at first egg were reported by Ferdoci et al. (1992), Sharma et al. (1999), Singh et al. (1999) and Sethi et al. (2003). Negative genetic correlation between body weight at 20 weeks and age at first egg was reported by various workers (Sharma et al., 1994; Singh et al., 2001).

Body weight at 20 weeks had a negative phenotypic correlation with age at first egg in G_1, G_2, G_4, G_5 and positive in G_3 generations. Positive phenotypic correlation between body weight at 20 weeks and age at first egg was reported by Singh et al. (1999) and Sethi et al. (2003). However, the negative phenotypic correlation between body weight at 20 weeks and age at first egg was reported by various workers (Ferdoci et al.,1992; Sharma et al., 1994; Sharma et al., 1999; Singh et al., 2001).

Correlation of 20 Week Body Weight with Egg Weight

Body weight at 20 weeks was found to be negatively associated with egg weight in G_1, G_5 and positively associated in G_2, $G_{3,}$ and G_4generations at the genetic level. Negative genetic correlation between 20 week body weight and egg weight were reported by Sharma et al. (1994) and Narwhal (1999), whereas positive genetic correlation between 20 -weeks body weight and egg weight as reported by several workers (Kalita and Das, 1986; Singh et al., 1986;Ferdoci et al., 1992; Sethi et al., 2003).

Phenotypic correlation between 20 -week body weight and egg weight was found to be positive for all generations (except G_3 generation). Ferdoci et al. (1992), Sharma et al. (1994), Narwhal (1999) and Sethi et al. (2003) reported positive phenotypic correlation between 20 -week body weight and egg weight, where as Kalita and Das (1986) reported negative phenotypic correlation between 20- week body weight and egg weight.

Correlation Between 20 Week Body Weight and Egg Number upto 40 Weeks Age

Genetic correlation of 20 -week body weight was found to be positive with egg number up to 40 weeks in all generations (except G_2). Ferdoci et al. (1992), Sharma et al. (1994), Singh et al. (1999) and Sethi et al. (2003) reported a positive genetic correlation between 20- week body weight and egg number up to 40 weeks of age. Negative genetic correlation between 20- week body weight and egg number up to 40 weeks has been reported by Singh et al. (2001).

Table 2: Genetic Correlations (Above Diagonal) and Phenotypic Correlations (below diagonal) Among Performance Traits (Generation-1)

Traits	BW_{20}	AFE	EW	EN_{40}	EN_{50}
BW_{20}	-	0.077±0.261	-0.192±0.231	0.353±0.214	-0.089±0.206
AFE	-0.016±0.049	-	-0.196±0.238	-0.800±0.243	-0.394±0.196
EW	0.042±0.049	0.057±0.049	-	-0.121±0.048	0.281±0.205
EN_{40}	0.088±0.049	-0.225±0.034	-0.187±0.044	-	0.806±0.070
EN_{50}	0.131±0.070	-0.222±0.069	-0.045±0.071	0.777±0.031	-

Table 3: Genetic Correlations (Above Diagonal) and Phenotypic Correlations (Below Diagonal) Among Performance Traits (Generation-2)

Traits	BW_{20}	AFE	EW	EN_{40}	EN_{50}
BW_{20}	-	-0.345±0.330	0.074±0.373	0.059±0.304	-0.126±0.213
AFE	-0.078±0.046	-	0.760±0.308	-0.621±0.284	-0.347±0.198
EW	0.208±0.046	0.100±0.047	-	-0.219±0.045	-0.331±0.231
EN_{40}	0.072±0.047	-0.176±0.046	-0.277±0.044	-	0.346±0.194
EN_{50}	0.071±0.072	-0.299±0.070	-0.145±0.071	0.675±0.053	-

Table 4: Genetic Correlations (Above Diagonal) and Phenotypic Correlations (Below Diagonal) Among Performance Traits (Generation-3)

Traits	BW_{20}	AFE	EW	EN_{40}	EN_{50}
BW_{20}	-	0.049±0.284	0.320±0.275	0.092±0.273	-0.409±0.218
AFE	0.110±0.052	-	-0.397±0.235	-0.502±0.225	-0.778±0.215
EW	-0.106±0.052	0.097±0.052	-	-0.149±0.052	0.203±0.240
EN_{40}	0.225±0.051	-0.247±0.051	-0.234±0.051	-	0.130±0.251
EN_{50}	0.114±0.078	-0.390±0.072	-0.010±0.078	0.476±0.069	-

Table 5: Genetic Correlations (Above Diagonal) and Phenotypic Correlations (Below Diagonal) Among Performance Traits (Generation-4)

Traits	BW_{20}	AFE	EW	EN_{40}	EN_{50}
BW_{20}	-	-0.675±0.574	0.392±0.214	0.641±0.355	-0.220±0.243
AFE	-0.114±0.035	-	0.346±0.201	-0.372±0.257	-0.141±0.251
EW	0.042±0.035	0.155±0.035	-	-0.115±0.035	-0.438±0.193
EN_{40}	0.072±0.036	-0.469±0.031	-0.182±0.010	-	0.771±0.084
EN_{50}	0.003±0.067	-0.272±0.065	-0.203±0.066	0.815±0.039	-

Table 6: Genetic Correlations (Above Diagonal) and Phenotypic Correlations (Below Diagonal) Among Performance Traits (Generation-5)

Traits	BW_{20}	AFE	EW	EN_{40}	EN_{50}
BW_{20}	-	-0.218±0.224	-0.249±0.287	0.280±0.243	-0.089±0.230
AFE	-0.167±0.035	-	0.636±0.173	-0.746±0.172	-0.270±0.219
EW	0.041±0.035	0.029±0.035	-	-0.068±0.035	-0.420±0.198
EN_{40}	0.083±0.035	-0.486±0.031	-0.162±0.043	-	0.676±0.124
EN_{50}	0.072±0.051	-0.269±0.050	-0.101±0.051	0.770±0.033	-

Phenotypic correlation of 20 -week body weight was found to be positive with egg number up to 40 weeks of age in all generations. Positive phenotypic correlation between these traits has been reported by most of the earlier workers (Ferdoci et al., 1992; Sharma et al., 1994; Singh et al., 2001; Sethi et al., 2003) which is in accordance with the present results.

Correlation Between 20 Week Body Weight and Egg Number upto 50 Weeks Age

Body weight at 20 weeks was found to be negatively associated with egg number up to 50 weeks in all the generations at the genetic level. Negative genetic association between these traits has been reported by Mishra et al. (1992), Singh (1996) and Singh et al. (2001). Phenotypic correlation of 20- week body weight and egg number up to 50 weeks was positive in all generations. Mishra et al. (1992), Singh (1996) and Singh et al. (2001) reported the association of these traits in accordance with the present findings.

Correlation of Age at First Egg with Egg Weight

Age at first egg had a negative genetic correlation with egg weight in G_1 and G_3 generations, while positive correlation in G_2, $G_{4,}$ and G_5 generations. Singh et al. (1986) and Narwhal (1999) reported negative genetic correlation between these traits and Ferdoci et al. (1992), Sharma et al. (1994), Sethi et al. (2003), Vasu et al. (2004) and Singh et al. (2004) reported positive genetic correlation between age at first egg and egg weight.

Phenotypic correlation of age at first egg and egg weight was positive in all the generations. A Positive correlation between these traits at phenotypic level has also been reported by Ferdoci et al. (1992), Sharma et al. (1994), Sethi et al. (2003) and Singh et al. (2004).

Correlation of Age at First Egg with Egg Number up to 40 and 50 Weeks of Age

Age at first egg was negatively associated with egg number up to 40 and 50 weeks of age at genetic as well as phenotypic level in all the generations. In accordance to the present results, negative genetic and phenotypic correlations between these traits have been reported by most of the earlier workers (Ferdoci et al.,1992; Mishra et al.,1992; Sharma et al., 1994; Singh,1996; Singh et al., 2001;).

From present results, it may be inferred that direct selection for high egg number may lower down the age at sexual maturity concomitantly. The negative genotypic and phenotypic correlation among these traits indicated that early maturing pullets laid more eggs up to 40 weeks of age. Hence, a strong negative association between these traits will be beneficial to the breeder as long as there is no adverse impact on egg weight.

Correlation of Egg Weight and Egg Number up to 40 Weeks of Age

Egg weight was negatively associated with egg number up to 40 weeks of age at genetic as well as phenotypic level in all the generations. Ferdoci et al. (1992) and Singh et al. (2004) reported negative genetic and phenotypic correlation between these traits which is in accordance with the present findings.

Correlation of Egg Weight and Egg Number up to 50 Weeks of Age

Egg weight was positively associated with egg number up to 50 weeks of age at the genetic level in G_1 and G_3 generations and negatively in G_2, $G_{4,}$ and G_5 generations. Atkare and Khan (1988) reported positive genetic correlation whereas Vasu et al. (2004) reported a negative genetic correlation between these traits.

Phenotypic correlation between egg weight and egg number up to 50 weeks of age was negative in all the generations. Similar to the present results, Vasu et al. (2004) reported a negative phenotypic correlation between these traits.

Correlation Between Egg Number up to 40 Weeks and 50 Weeks of Age

Egg production upto 40 weeks of age was positively associated with egg production up to 50 weeks of age at genetic as well as phenotypic level in all the generations. Atkare and Khan (1988)and Singh (1996) reported positive genetic and phenotypic correlation between these traits which is similar to the present results.

Estimates of genetic and phenotypic correlations among production traits from the data pooled over generations (Table 7) revealed that body weight at 20 weeks of age had a positive association with age at first egg, egg weight and egg number at the phenotypic level. Age at first egg and egg weight had a negative correlation with egg number up to 40 and 50 weeks age both at genetic and phenotypic level.

Table 7: Genetic Correlations (Above Diagonal) and Phenotypic Correlations (Below Diagonal) Among Performance Traits (Pooled Over Generation)

Traits	BW_{20}	AFE	EW	EN_{40}	EN_{50}
BW_{20}	-	0.109±0.126	-0.070±0.123	0.227±0.122	-0.106±0.124
AFE	0.005±0.018	-	0.037±0.122	-0.282±0.126	-0.288±0.126
EW	0.003±0.018	0.063±0.018	-	-0.183±0.018	-0.268±0.120
EN_{40}	0.112±0.018	-0.248±0.018	-0.423±0.115	-	0.656±0.066
EN_{50}	0.013±0.029	-0.229±0.028	-0.116±0.029	0.760±0.019	-

CONCLUSIONS

There existed a negative genetic correlation between age at first egg and egg weight at the genetic level, while positive low association at the phenotypic level. Egg number up to 40 and 50 weeks of age were positively high associated both at genetic and phenotypic level. In general, the standard errors of genetic correlations were higher than the estimates indicating the poor precision of genetic correlations.

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